Original Article

The Use of Central Venous Catheters in the Management of Pleural Effusion in a Tertiary Hospital in Cebu City

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ABSTRACT

Background: There is limited data on the use of central venous catheters (CVCs) in the drainage of pleural effusions. The study aimed to describe the use of CVCs for this purpose.

Methodology: This was a cross-sectional descriptive study done in a tertiary hospital in Cebu City. All patients aged ≥18 years old with pleural effusion who underwent CVC, pigtail catheter, or chest tube thoracostomy (CTT) insertion for pleural fluid drainage were included. Data collected included total drainage of pleural fluid, average daily pleural fluid drainage, duration of catheter use, complications, number of patients sent home with catheters, and number of pleurodesis performed.

Results: A total of 229 patients were included in the study (CVC: 114, pigtail: 22, CTT: 93). Transudative pleural effusion was more frequently encountered in the CVC group (18.78%). Malignancy (28.95%), congestive heart failure (22.81%), tuberculosis (15.79%), pneumonia (15.79%), and chronic kidney disease (14.91%) were the more common causes of pleural effusion in the CVC group. The average daily pleural fluid output and total pleural fluid drainage were highest in the CVC group (527.5 ± 284.9 mL and 5020.47 ± 5691.29 mL, respectively). The duration of catheter use was similar in the three groups. The number of patients sent home with catheters and the number of pleurodesis performed were observed to be highest in the CVC group (48.12% and 61.11%, respectively). Accidental removal was most frequently observed in the CVC group (8/12) although the overall incidence was low at 5.24%. Pneumothorax occurred most frequently in the CTT group (53/64).

Conclusions: The study demonstrates the use of CVCs as an alternative drainage procedure for pleural effusions of various causes. CVCs can also provide an access to perform pleurodesis. A low incidence of complications was observed. Further studies are needed to establish the efficacy and safety of CVCs.

Keywords: central venous catheter, pigtail catheter, chest tube thoracostomy, indwelling pleural catheter

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INTRODUCTION

Background of the study

Large pleural effusions can cause atelectasis of the involved lung, causing significant symptoms such as cough and dyspnea.[1] Therefore, interventions to remove the pleural fluid and expand the affected lung should be undertaken. Traditionally, recurrent pleural effusions were managed with repeated thoracenteses.[2] However, the repeated punctures may cause patient discomfort and are associated with complications such as pneumothorax and bleeding. At present, common practices to drain pleural effusion include thoracentesis under ultrasound guidance, insertion of a pigtail catheter, and placement of a large-bore closed tube thoracostomy (CTT). However, placement of large-bore chest tubes (French 24-32) is inconvenient as the procedure needs to be done in the operating room, results in more pain and discomfort for the patient, and is associated with higher cost. Pigtail catheter (French 10) is another option for pleural fluid drainage but it may not be available in some settings and may require referral to a surgeon or interventional radiologist. Despite the limitations, the introduction of indwelling pleural catheters, an example of which is the pigtail catheter, has changed the landscape of the management of recurrent pleural effusion, particularly malignant pleural effusion.[2] They were approved by the FDA in 1997 and are now considered the treatment of choice in malignant pleural effusion with evidence to support their use in other causes of recurrent pleural effusion as well.[2]

A central venous catheter (CVC) is an indwelling catheter that is inserted into a large central vein, most commonly the internal jugular, subclavian, or femoral vein.[3] This catheter is commonly used as access for medication, dialysis, total parenteral nutrition, hemodynamic monitoring, and interventions such as transvenous pacemaker placement.[3] However, CVCs (French 7) have been used off-label to drain large effusions or recurrent effusions. The advantages include avoidance of repeated thoracenteses, therefore, reducing the complications of frequent puncture and causing less patient discomfort as compared to large-bore CTT. In addition, CVCs can be inserted at bedside under ultrasound guidance, making it convenient and less costly.[1]

There is limited literature on the use of CVCs in the drainage of pleural effusions. Singh et al prospectively studied 10 patients and found that CVCs effectively drained large pleural effusions with no major complications.[1] Yazdanbod et al retrospectively studied 84 patients with malignant effusions who underwent triple-lumen CVC insertion, reporting a median catheter duration of 38 days, with no post-procedure complications, and significant improvement in quality of life at 30 and 60 days.[4] Song et al retrospectively studied 104 patients with tuberculous pleurisy and compared CVC drainage to standard pleural puncture.[5] The CVC group had a faster resolution of effusion, shorter hospital stay, and fewer complications (1.9% vs 15.4%; $p < 0.05$) despite draining a lower total fluid volume.[5] Similarly, Wu et al conducted a prospective study of 104 patients with pneumoconiosis-related pleural effusions, finding that CVC drainage led to higher fluid output, faster effusion resolution, and a significantly higher cure rate (83.33% vs 46.43%; $p < 0.01$) compared to repeated thoracenteses.[6] These

studies suggest that CVCs may be a safe and effective alternative for pleural effusion drainage, particularly in cases requiring repeated interventions.

In our institution, CVC insertion under ultrasound guidance is the common method of drainage for non-loculated or recurrent pleural effusion to facilitate weaning in patients who require oxygen support and to provide symptomatic relief of dyspnea. Chest tube thoracostomy, on the other hand, is usually reserved for complicated or loculated pleural effusion.

Research question
What are the demographic and clinical characteristics of patients managed for pleural effusion, the pleural fluid properties, drainage outcomes, and complication rates across three different types of pleural fluid drainage procedures (CVC, pigtail catheter, CTT)?

Objectives
General objective
To describe the use of CVCs in the drainage of pleural effusions and compare with other drainage procedures (pigtail catheter and CTT).

Specific objectives
1. To describe the baseline demographic and clinical characteristics of patients with pleural effusion in whom central venous catheters (CVCs) were inserted in Chong Hua Hospital and compare with those who underwent other drainage procedures:
    A. Age
    B. Gender
    C. Comorbidities
        - Heart failure
        - Malignancy
        - Renal disease
        - Liver disease
        - Pneumonia
        - Pulmonary tuberculosis
    D. Pleural fluid characteristics
        - Color and turbidity
        - Differential count (red blood cell, white blood cell, polymorphonuclear neutrophils, lymphocytes)
        - Total protein
        - Lactate dehydrogenase
        - Culture
        - Exudative
        - Transudative
2. To identify common causes of pleural effusion in patients who received CVC drainage and compare with those who underwent other drainage procedures
3. To determine the total pleural fluid drained and average pleural fluid output per day using CVCs and compare with other drainage procedures
4. To determine the average duration of use of CVCs for pleural fluid drainage and compare with other drainage procedures
5. To identify complications with the use of CVCs for pleural fluid drainage and compare with other drainage procedures

METHODOLOGY
Study design
This was a a cross-sectional descriptive study.

Study setting
The study was conducted in Chong Hua Hospital, a 660-bed capacity private tertiary hospital in Cebu City.

Study population
The study included patients admitted at Chong Hua Hospital who were 18 years old and above with radiographic or sonographic evidence of pleural effusion who underwent insertion of CVC, pigtail catheter, or large-bore chest tube from January 2018 to July 2023.

Data collection
Data on patients admitted at Chong Hua Hospital with a discharge diagnosis of pleural effusion who underwent CVC, pigtail catheter, or chest tube insertion were obtained through a computerized registry. Patients' baseline characteristics as well as the total amount of pleural fluid drained, average amount of pleural fluid drained per day, duration of catheter use, associated complications, number of patients sent home with catheters, and number of pleurodesis performed were collected from a retrospective chart review.

Data analysis
Frequencies and percentages were determined for the baseline characteristics of the study population. The mean and standard deviation were determined for the total pleural fluid output, daily pleural fluid output, and duration of catheter use.

Ethical considerations
Review and approval of the research protocol by the Institutional Review Board of Chong Hua Hospital was done prior to commencement of the study (IRB reference code 1123-02). Informed consent was waived as the study involved a retrospective chart review. Personal data of all patients included in the study remained confidential. This study adhered to the principles outlined in the Declaration of Helsinki.

RESULTS
A total of 229 patients were included in the study, with 114 patients in the CVC group, 22 patients in the pigtail group, and 93 patients in the CTT group. Table 1 shows the baseline demographics of patients included in this study. The overall mean age was 61.06 ± 18.49 years with a younger patient population (53.26 ± 19.6 years) in the CTT group. Among the CVC group, chronic kidney disease (38.6%) and heart failure (30.70%) were the most prevalent comorbidities. Yellowish pleural fluid was most frequently observed in the CVC group (73/122; 59.84%) while reddish pleural fluid was most frequently encountered in the CTT group (47/83; 56.63%). The pleural fluid neutrophil count was highest in the CTT group (27.25 ± 30.19%). On the other hand, the pleural fluid lymphocyte count was highest in the CVC group (74.85 ± 28.68%). The pleural fluid total protein was highest in the pigtail catheter group (7.3 ± 21.02 g/dL) while pleural fluid LDH was highest in the CTT group (851.69 ± 2462 U/L). Bacterial growth on pleural fluid culture was most frequently observed in the CTT group (17/21; 80.95%). Transudative pleural effusion was most frequently encountered in the CVC group (43/54; 79.63%). There was a total of 9 cases of bilateral catheter insertion for bilateral pleural effusion which was most frequently observed in the CVC group (5/9; 55.56%).

Table 2 shows the primary causes of pleural effusion in patients who underwent CVC, pigtail catheter, and CTT insertion. Malignancy (35.48%), pulmonary tuberculosis

Table 1. Baseline characteristics of patients with pleural effusion

	Overall (n = 229)	Central venous catheter (n = 114)	Pigtail catheter (n = 22)	Chest tube thoracostomy (n = 93)
Age, mean ± SD	61.06 ± 18.49	66.14 ± 15.47	67.68 ± 16.81	53.26 ± 19.6
Gender, n (%)				
Female	102 (44.54)	49 (42.98)	13 (59.09)	40 (43.01)
Male	127 (55.46)	65 (57.02)	9 (40.91)	53 (56.99)
Comorbidities, n (%)				
Heart Failure	49 (21.40)	35 (30.70)	6 (27.27)	8 (8.60)
Malignancy	77 (33.62)	33 (28.95)	10 (45.45)	34 (36.56)
Liver disease	27 (11.79)	11 (9.65)	3 (13.64)	13 (13.98)
Chronic kidney disease	49 (21.40)	44 (38.60)	1 (4.55)	4 (4.30)
Pneumonia	83 (36.24)	41 (35.96)	8 (36.36)	34 (36.56)
Pulmonary tuberculosis	49 (21.40)	20 (17.54)	3 (13.64)	26 (27.96)
Color, n (%)				
Yellow	122 (53.28)	73 (64.04)	14 (63.64)	35 (37.63)
Red	83 (36.24)	29 (25.44)	7 (31.82)	47 (50.54)
Turbidity, n (%)				
Clear	2 (0.87)	1 (0.88)	1 (4.55)	0 (0)
Turbid	204 (89.08)	104 (91.23)	20 (90.91)	80 (86.02)
Differential count, mean ± SD				
RBC (mm^3)	25252.6 ± 72023.27	19024.6 ± 75362.84	18636.36 ± 35644.31	34452.06 ± 73793.9
WBC (mm^3)	3133.61 ± 28945.86	1064.03 ± 1757.17	1089.59 ± 1199.96	6154.05 ± 45351.87
PMN (%)	21.73 ± 24.59	17.25 ± 19.06	21.68 ± 19.28	27.25 ± 30.19
Lymphocyte (%)	67.34 ± 33.23	74.85 ± 28.68	69.23 ± 28.72	57.69 ± 37.06
Total protein (g/dL), mean ± SD	3.77 ± 6.77	3.4 ± 1.85	7.3 ± 21.02	3.39 ± 2.27
LDH (U/L), mean ± SD	488.66 ± 1656.29	187.32 ± 241.49	515.55 ± 1355.84	851.69 ± 2462
Culture, n (%)				
With growth	21 (9.17)	1 (0.88)	3 (13.64)	17 (18.28)
No growth	183 (79.91)	104 (91.23)	13 (59.09)	66 (70.97)
Exudative, n (%)	125 (54.59)	58 (50.88)	13 (59.09)	54 (58.06)
Transudative, n (%)	54 (23.58)	43 (37.72)	5 (22.73)	6 (6.45)
Unilateral insertion, n (%)	220 (96.07)	109 (95.61)	21 (95.45)	90 (96.77)
Bilateral insertion, n (%)	9 (3.93)	5 (4.39)	1 (4.55)	3 (3.23)

RBC, red blood cell; WBC, white blood cell; PMN, polymorphonuclear neutrophils; LDH, lactate dehydrogenase

Table 2. Primary causes of pleural effusion in patients who underwent CVC, pigtail catheter, and CTT insertion

n (%)	Overall (n = 229)	Central venous catheter (n = 114)	Pigtail catheter (n = 22)	Chest tube thoracostomy (n = 93)
Malignancy	75 (32.75)	33 (28.95)	9 (40.91)	33 (35.48)
Tuberculosis	52 (22.71)	18 (15.79)	4 (18.18)	30 (32.26)
Pneumonia	32 (13.97)	18 (15.79)	1 (4.55)	13 (13.98)
Heart failure	36 (15.72)	26 (22.81)	5 (22.73)	5 (5.38)
Chronic kidney disease	20 (8.73)	17 (14.91)	1 (4.55)	2 (2.15)
Liver disease	12 (5.24)	10 (8.77)	1 (4.55)	1 (1.08)
Empyema	7 (3.06)	0 (0)	0 (0)	7 (7.53)

(32.26%), and pneumonia (13.98%) were the more common etiologies of pleural effusion in the CTT group. Moreover, empyema thoracis was the primary indication for drainage with CTT in all empyema cases (n = 7). On the other hand, malignancy (28.95%), congestive heart failure (22.81%), tuberculosis (15.79%), pneumonia (15.79%), and chronic kidney disease (14.91%) were the more common causes of pleural effusion in the CVC group. Liver disease was the primary indication for pleural fluid drainage in 8.77% of cases in the CVC group.

Table 3 shows the average pleural fluid output per day, total pleural fluid drainage, duration of catheter use, number of patients sent home with catheter, and number of pleurodesis performed in patients who underwent CVC, pigtail catheter, and CTT insertion. The average pleural fluid output per day and total pleural fluid drainage were observed to be highest in the CVC group (527.5 ± 284.9 mL and 5020.47 ± 5691.29 mL, respectively). The duration of catheter use (in hospital days) was similar in the three groups. The number of patients sent home with catheters and the number of pleurodesis performed were observed to be highest in the CVC group (64/133; 48.12% and 33/54; 61.11%, respectively).

Table 4 presents the complications encountered in patients who underwent CVC, pigtail catheter, and CTT insertion. A low incidence of bleeding, infection, and obstruction was observed across all catheter types. Accidental removal was most frequently observed in the CVC group (8/12; 66.67%) although the overall incidence was low at 5.24%. Pneumothorax occurred most frequently in the CTT group (53/64; 82.81%). Six patients in the CVC group (6/114; 5.26%) subsequently underwent CTT insertion due to complicated pleural effusion.

Table 5 shows the cost of the use of CVC, pigtail catheter, and CTT in our institution excluding professional fees. CVC

Table 3. Average pleural fluid output per day, total pleural fluid drainage, duration of catheter use, number of patients sent home with catheter, and number of pleurodesis performed in patients who underwent CVC, pigtail catheter, and CTT insertion

	Overall (n = 229)	Central venous catheter (n = 114)	Pigtail catheter (n = 22)	Chest tube thoracostomy (n = 93)
Average pleural fluid output per day, mL (mean ± SD)	443.75 ± 291.4	527.5 ± 284.9	378.68 ± 197.79	356.48 ± 290.54
Total pleural fluid drainage, mL (mean ± SD)	4070.44 ± 4699.39	5020.47 ± 5691.29	3132.55 ± 4079.21	3127.74 ± 2986.79
Duration of catheter use, hospital days (mean ± SD)	11.79 ± 14.38	12.54 ± 16.88	10.32 ± 10.46	11.22 ± 11.66
Patients sent home with catheter, n (%)	133 (58.08)	64 (56.14)	13 (59.09)	56 (60.22)
Pleurodesis performed, n (%)	54 (23.58)	33 (28.95)	3 (13.64)	18 (19.35)

Table 4. Complications encountered in patients who underwent CVC, pigtail catheter, and CTT insertion

n (%)	Overall (n = 229)	Central venous catheter (n = 114)	Pigtail catheter (n = 22)	Chest tube thoracostomy (n = 93)
Bleeding	3 (1.31)	1 (0.88)	2 (9.09)	0 (0)
Pneumothorax	64 (27.95)	11 (9.65)	0 (0)	53 (56.99)
Infection	8 (3.49)	4 (3.51)	0 (0)	4 (4.30)
Accidental removal	12 (5.24)	8 (7.02)	1 (4.55)	3 (3.23)
Obstruction	4 (1.75)	3 (2.63)	0 (0)	1 (1.08)

Table 5. Comparison of the costs for CVC, pigtail catheter, and CTT insertion

	Central venous catheter	Pigtail catheter	Chest tube thoracostomy
Cost of catheter	Php 5,000	Php 8,000	Php 1,000
Cost of procedure	Php 22,000	Php 30,000	Php 30,000
Total cost	Php 27,000	Php 38,000	Php 31,000

insertion has the lowest cost among the three types of catheters.

DISCUSSION

This study has provided an overview of the use of CVCs as indwelling pleural catheters for the drainage of pleural effusions of various etiologies in our institution. CVCs were used in patients with transudative pleural effusions due to congestive heart failure and chronic kidney disease as well as in those with exudative effusions caused by malignancy, tuberculosis, and pneumonia. In contrast, higher pleural fluid LDH and positive cultures were more frequently encountered in the CTT group as CTT is the most common drainage procedure for complicated, loculated, and infected pleural effusion in our institution. The higher pleural fluid output in the CVC group may be due to conditions causing recurrent pleural effusion (e.g., malignancy, congestive heart failure, chronic kidney disease). Singh et al reported the use of CVCs for the drainage of pleural effusion of various causes such as liver disease, cardiac disease, pneumonia, and pancreatitis.[1] Yazdanbod et al similarly described the use of CVC for the drainage of malignant pleural effusion, with significant improvement in the quality of life.[4] Song et al reported the use of CVC for the drainage of tuberculous pleural effusion, with significant early improvement in the pleural effusion, chest pain, and fever.[5]

A noteworthy finding was the lower incidence of complications encountered in the CVC group. Pneumothorax was observed to be more frequent in patients who underwent CTT insertion which might be due to the more traumatic nature of inserting a large-bore tube. A reddish pleural fluid was likewise more frequently seen in the CTT group due to the larger wound incision required. Accidental removal was more frequently observed in the CVC group although the incidence was low. In our institution, CVC is inserted as an indwelling pleural catheter under ultrasound guidance. In some instances, CVCs are not secured with sutures to facilitate easier removal which might explain the higher rates of accidental removal in this study. The conversion rate to closed tube thoracostomy in patients with CVC was observed to be low in this study which shows that CVCs may provide adequate drainage without the need for escalation to a more invasive procedure. Song et al reported significantly lower complications with the use of CVCs compared to conventional pleural puncture and drainage for the management of tuberculous pleural effusion.[5] Moreover, the authors highlighted several advantages of CVCs for pleural fluid drainage including reduced need for repeated thoracentesis, fewer procedural complications, and greater patient comfort compared to large-bore chest tubes.[1] Pleurodesis, which is an important aspect of pleural effusion management, can also be performed using CVCs, as demonstrated in the study. Successful pleurodesis through CVC was described by Ghoneim et al in hepatic hydrothorax.[9]

Further, this study highlights the low cost associated with CVC insertion in the long-term management of pleural effusion. Among the three drainage methods, CVCs had the lowest total cost. The ability to insert CVCs at the bedside under ultrasound guidance, without the need for an operating room, likely contributes to its lower procedural costs.[1] CVC insertion also allows patients to be sent home for continued drainage which may further reduce hospitalization costs, particularly in those with malignant or recurrent effusions. CVCs for pleural fluid drainage can be particularly advantageous in resource-limited settings where access to operating rooms and specialized procedures is restricted. The minimally-invasive nature, ease of placement, and associated patient comfort make them a practical alternative when dedicated pleural drainage devices are unavailable.

The off-label use of CVCs for pleural fluid drainage may raise important ethical considerations particularly regarding patient safety, informed consent, and adherence to best clinical

practices. While CVCs are not specifically designed for this purpose, the authors believe that their use may be justified in scenarios where alternative drainage devices are unavailable especially in resource-limited settings. Informed consent was obtained prior to CVC insertion in patients included in this study as routine for these procedures. The risks and benefits were also explained to patients. While off-label use of medical devices is not inherently unethical, the acceptability of using CVCs for pleural drainage hinges on the principle of beneficence—maximizing patient benefit while minimizing harm. Given the low complication rates, low cost and broad availability, CVCs may provide a practical alternative for pleural fluid drainage in specific clinical scenarios.

Limitations

This study was done as a six-year retrospective chart review. The study was conducted in a single institution which may limit generalizability of the findings to other healthcare settings. The retrospective nature of data collection also introduced the potential for documentation bias. The total duration of pleural catheter use included in-patient days of catheter use only, with some patients being sent home with catheters. The initial volume of pleural effusion on ultrasound prior to catheter insertion was not included in the study. Re-expansion pulmonary edema, as a rare complication of pleural fluid drainage, was not documented in some of the cases, hence, was not included in this study.

Recommendations

A prospective study on the use of CVCs for the drainage of pleural effusions is recommended to establish its efficacy and safety in comparison to other types of indwelling catheters. Moreover, a subgroup analysis focusing on recurrent pleural effusions—such as those caused by malignancy, congestive heart failure, chronic kidney disease, and liver disease, where CVCs were more commonly used—is recommended. A cost-effectiveness analysis may also be performed in future prospective studies.

CONCLUSION

This study provides an overview of the use of CVCs as an alternative drainage procedure for non-complicated pleural effusion. CVC has been used in pleural effusions of various causes and has a low incidence of complications. Moreover, it provides an access through which pleurodesis can be performed.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Authors' Disclosure

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References

1. Singh, K, Loo, S, Bellomo, R. (2003). Pleural drainage using central venous catheters. *Critical Care*. 2003;7(6):R191-194. https://doi.org/10.1186/cc2393
2. Siddiqui, F, Ihle, RE, Siddiqui AH. Intrapleural catheter. In StatPearls. StatPearls Publishing. Accessed May 11, 2025. http://www.ncbi.nlm.nih.gov/books/NBK493229/
3. Kolikof, J, Peterson, K, Baker, AM. Central venous catheter insertion. In StatPearls. StatPearls Publishing. Accessed May 11, 2025. http://www.ncbi.nlm.nih.gov/books/NBK557798/
4. Yazdanbod, A, Salehifar A, Maleki, N, Habibzadeh, S, Tavosi, Z. Successful use of central venous catheters in the management of recurrent malignant pleural effusions: One new option. *Supportive Care in Cancer.* 2015;23(8):2267–2271. https://doi.org/10.1007/s00520-014-2595-3
5. Song, L, Zhang, Y, Jia, Q. Central venous catheter based closed thoracic drainage in the treatment of tuberculous pleuritis. *Pakistan Journal of Medical Sciences.* 2019;35(4):1024–1029. https://doi.org/10.12669/pjms.35.4.63
6. Wu, S., Zhang, M. Central venous catheter for coal workers pneumoconiosis complicated with pleural effusion and pneumothorax efficacy analysis. *Chinese Journal of Industrial Hygiene and Occupational Diseases.* 2015; 33(1): 51-53. https://pubmed.ncbi.nlm.nih.gov/25876977/.
7. Chest tube insertion (Small bore catheter—CVC) evaluation form. Section of Pulmonary Medicine. Chong Hua Hospital
8. Cooke, DT and David, EA. Large-bore and small-bore chest tubes: Types, function, and placement. *Thoracic Surgery Clinics.* 2013;23(1):17–24. https://doi.org/10.1016/j.thorsurg.2012.10.006
9. Ghoneim, AHA, El Gammal, MS, AboZaid, MMN, El Rahman, AA. Efficacy of central venous catheter in pleurodesis in refractory hepatic hydrothorax. *The Egyptian Journal of Chest Diseases and Tuberculosis.* 2019;68(2):236. https://doi.org/10.4103/ejcdt.ejcdt_82_18